Modeling Variability in the Influence of Terrain and Vegetation on Snowpack: Findings and Implications for Water Management in Snowmelt-fed Regions

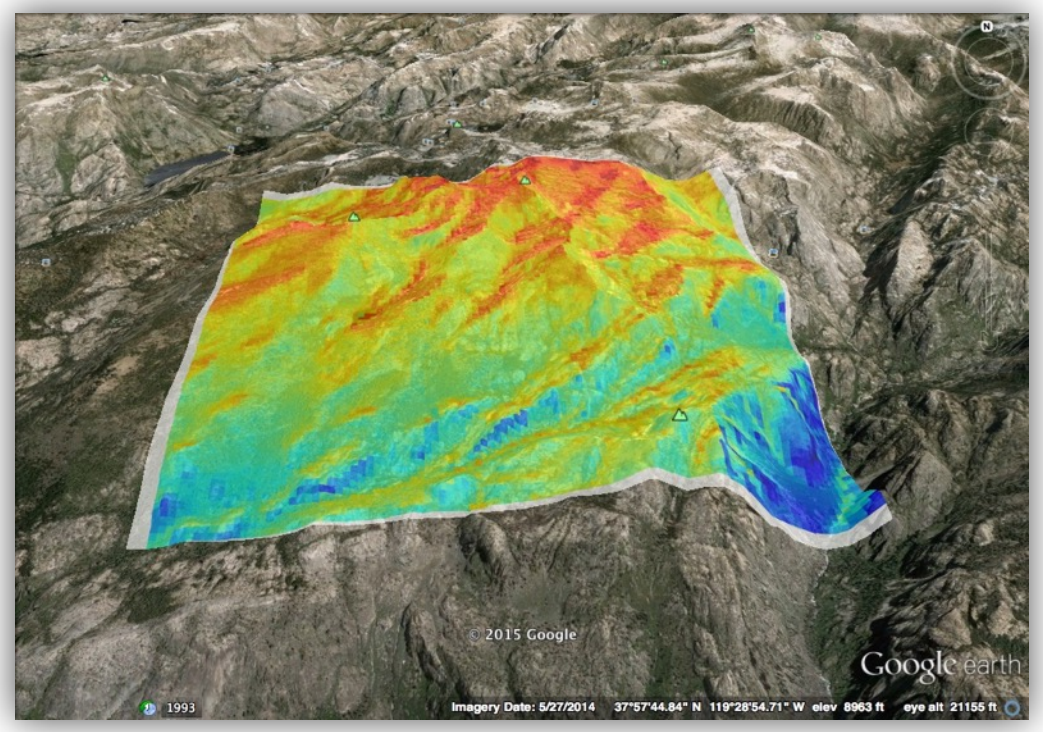
Ian W. Bolliger[1,2,3], Noah P. Molotch[4]

[1]Energy and Resources Group, UC Berkeley

[2]Civil and Environmental Engineering Department, UC Berkeley

[3]Global Policy Laboratory, UC Berkeley

[4]Department of Geography, Institute for Arctic and Alpine Research, University of Colorado Boulder



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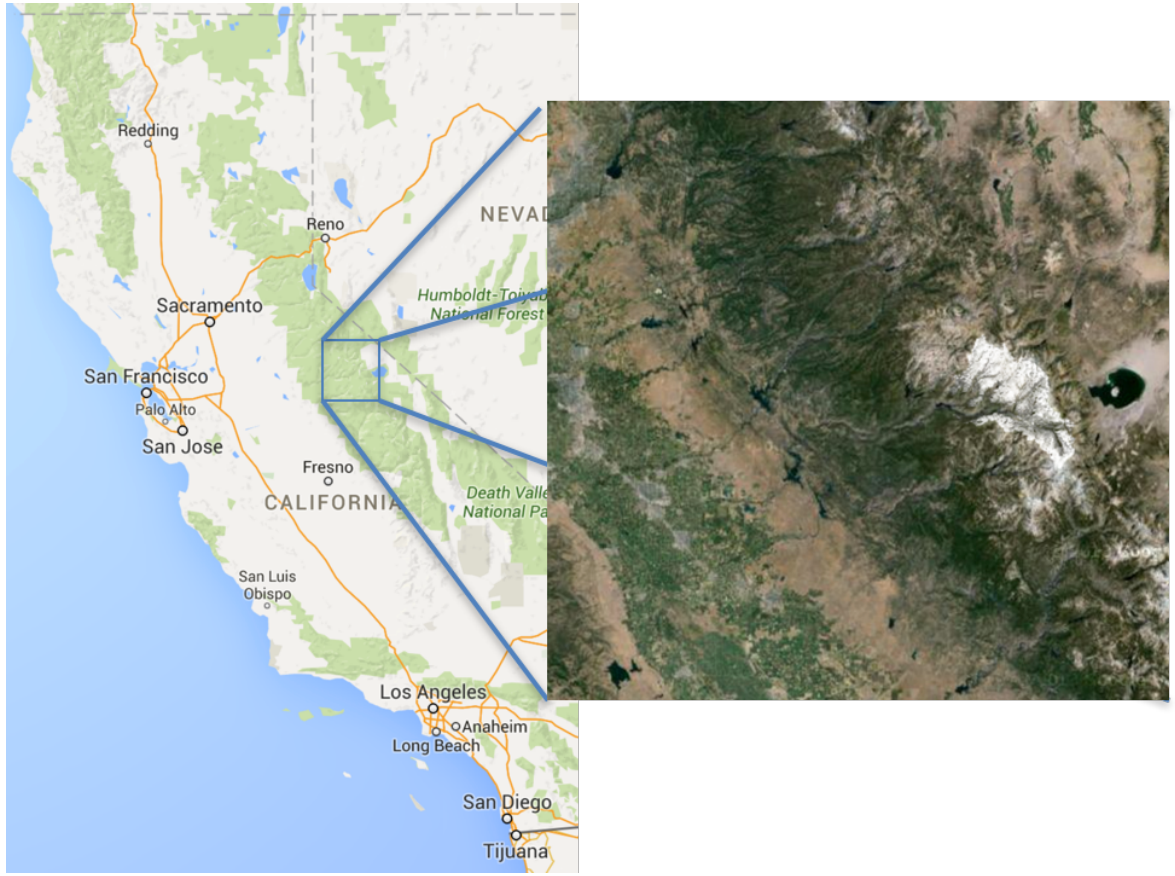
Abstract

- **Current State:** Operational methods for predicting water from seasonal snowmelt are imprecise and sparse.
- **Challenge #1:** Climate change will render historical relationships between point measurements of snow water equivalent (SWE, the amount of water contained in a column of snow) and summer streamflow invalid, necessitating new approaches to SWE measurement.
- **Challenge #2:** Terrain and vegetation-based models could aid snow distribution estimates, but little known about their stability across seasons, across years, or across model scales.
- **Opportunity:** New time series of gridded LiDAR-based snow measurements from the Tuolumne River Basin, with multiple collections between 2013-16.
- **This study:** Repeated regressions with numerous snapshots of gridded snow products (~70M pixels each) to assess model variability across time and scale.

Data and Methods

- Data: Tuolumne River Basin SWE and Snow Depth
  - 4 years (~10 dates per year) of 3m resolution “snapshots” of snow depth and SWE, ~1 GB per image
- Methods: Comparison of feature importance across random forest regressions fitted to each snapshot
  - Preprocessing: Parallel extraction of terrain features from Digital Elevation Map
  - Analysis: Parallel fitting of random forest models, themselves parallelized across ensemble members

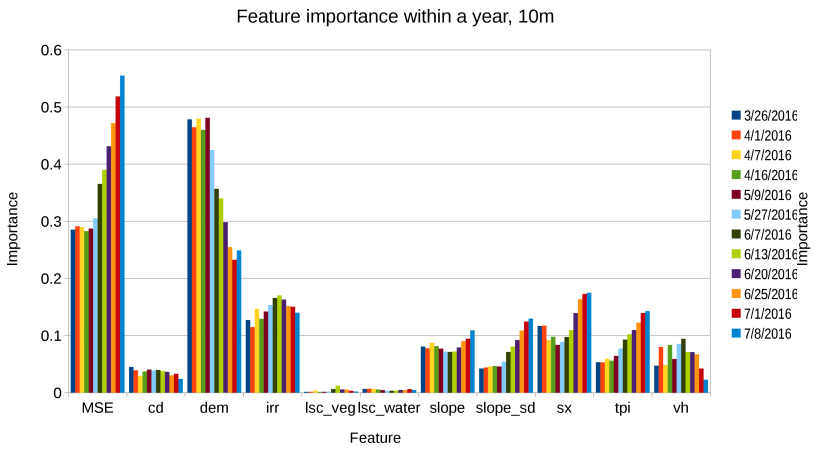


- Computational Tools: National Center for Atmospheric Research *Yellowstone* Supercomputer

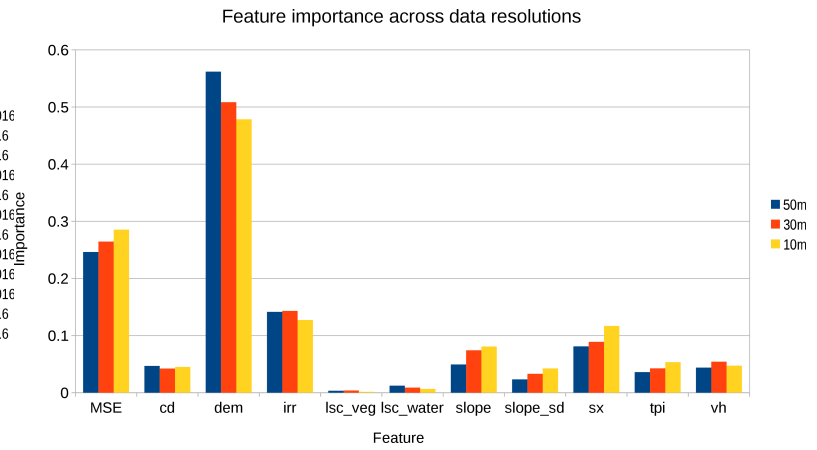
Preliminary Results

Comparisons of feature importance in random forest models across the indicated temporal/scale dimensions reveal several consistent patterns:

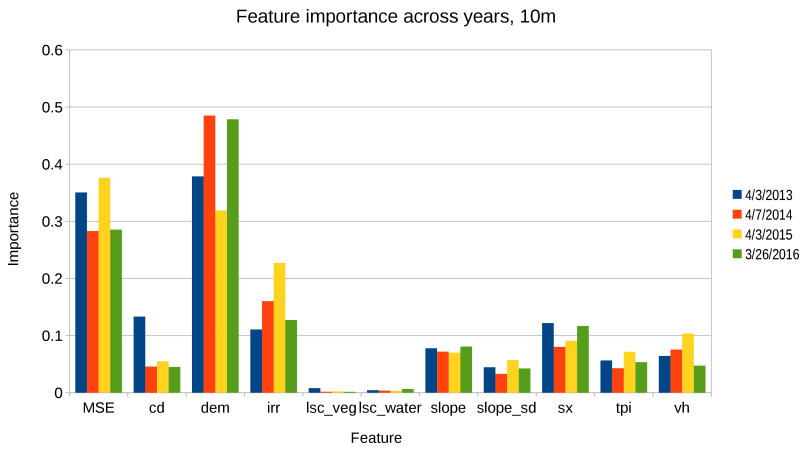
Intra-annual



Model Scale



Inter-annual



Conclusions

- Consistent intra-annual variability observed in feature influence
  - Elevation most predictive in early winter (accumulation phase), least in summer (ablation)
  - Clear-sky Irradiance most predictive in spring
- Terrain and vegetation features better predictors in accumulation phase
- Relative importance of elevation decreases with increasing model resolution
  - Fine-scale topographic features are only well represented at fine resolutions
- Terrain and vegetation features similarly important when predicting depth and SWE
- **Allowing for intraannual changes to model structure/parameters necessary for accurate snow distribution prediction using statistical terrain and vegetation-based models**

Acknowledgements

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